DOCUMENT RESUME

ED 303 336 SE 050 294

AUTHOR Gaides, G. Edward
TITLE Density: A Definition, a Concept, or Both?
INSTITUTION North Dakota Univ., Grand Forks. Center for Teaching and Learning.
PUB DATE 89
NOTE 9p.
PUB TYPE Guides - Classroom Use - Guides (For Teachers) (052) -- Collected Works - Serials (022)
JOURNAL CIT Insights into Open Education; v21 n5 Jan-Feb 1989

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Concept Formation; *Concept Teaching; Elementary Education; *Elementary School Science; Laboratory Experiments; *Laboratory Procedures; Physical Sciences; *Science Activities; Science Curriculum; Science Instruction; *Scientific Concepts
IDENTIFIERS *Density

ABSTRACT

Many words which have been treated in the denotative sense are actually connotative in nature. That is to say that citing a definition or stating a fact should not be a learning goal. Rather, a "conceptualization" should be what teachers are striving for. A series of activities dealing with density have been provided for demonstrations or laboratory type lessons at the elementary level. Activities include: (1) "Blocks of Wood"; (2) "Salt Water-Fresh Water"; (3) "Hot Water-Cold Water"; (4) "Liquid A-Liquid B"; and (5) "Blocks of Wood in Salt and Fresh Water." The materials needed, procedures, and explanations for each activity are described. (YP)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED303336

CENTER FOR TEACHING AND LEARNING
UNIVERSITY OF NORTH DAKOTA
GRAND FORKS 58202

Volume 21, Number 5
January/February 1989

Density: A Definition, A Concept, or Both?

by

G. Edward Gaides

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

X This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

J. Ferrone

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

SE 050 374

INSIGHTS into open education

BEST COPY AVAILABLE

Density: A Definition, A Concept, or Both?

By G. Edward Gaides
University of North Dakota
Grand Forks, ND

As a science educator, I seldom come in direct contact with the language used by experts in the reading/language arts area. However, as a result of team-teaching a course involving the integration of mathematics/science content with that of reading, I have become aware of the fact that many of the issues raised by those in reading are the same ones that we raise in the science field.

In particular, science teachers have long been concerned with moving away from the mere recall of factual information and definition toward what has been called a comprehension or an "understanding" of the subject matter. (Or, to use Bloom's Taxonomy, toward application, analysis, and evaluation.) In the area of reading, much has been written about helping students "understand more deeply--connotatively or conceptually, rather than merely on the surface . . ."* Many of the words which have been treated in the denotative sense are actually connotative in nature. That is to say that citing a definition or stating a fact should not be the learning goal. Rather, a "conceptualization" should be what we as teachers are striving for. In this latter case, the broad meaning of the "word" becomes part of the learner's conceptual network. As teachers, our efforts should be directed toward developing teaching strategies which have as their outcomes such objectives.

In order to illustrate this, density has been selected, not only because it is part of our everyday (non-scientific) vocabulary, but also because it is one of these words which is often treated in a denotative way when it should be approached connotatively.

For example, if a student (or an adult for that matter) is given a block of balsa wood and another of oak both of which have the same dimensions, the observation is soon made that the oak is heavier. Of course, this is correct. However, if the dimensions are changed and different samples used, then it would be possible to make the observation that the piece of balsa is heavier than the oak, that they may be of the same approximate weight, or that the observer cannot really tell which is heavier. (Again, these could be correct responses.) But what do all of the pieces of oak have in common and what do all of the balsa samples have in common? One such property is density.

When I have done the preceding activity with children or teachers, seldom is the notion of density used to describe the samples. I am confident that the reason for this is simply because density has been treated as a definition:

$$\text{Density} = \frac{\text{mass}}{\text{volume}}$$

Perhaps even a few problems have been worked involving this particular ratio. But this approach evidently is not sufficient to conceptualize density and make it a working, integral part of the

---

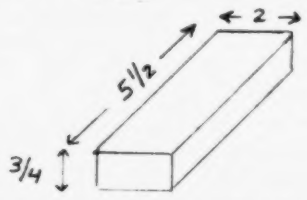
* *Deanna Strackbein, unpublished manuscript.*

vocabulary. (Otherwise, the term would have been used to describe the samples rather than simply "weight.")

In the sections which follow, a series of activities dealing with density have been provided. These may be performed as teacher demonstrations or, preferably, as laboratory type lessons with groups of children. It is anticipated that the activities will provide concrete examples of strategies that could be used to develop a conceptualization of density rather than a memorized definition which is soon forgotten.

ACTIVITY ONE
Blocks of Wood

MATERIALS: Oak, pine, and balsa samples work well. The first two woods may be obtained at a lumber yard and a convenient size board is the 1" x 6" (which actually measures 3/4 x 5 1/2 inches). Balsa is available at hobby/arts and crafts stores in various sizes. Unlike the oak and pine, dimensions are true measures. Therefore, a 3/4 x 2 inch x 3 foot length of balsa is desirable. These are cut into identical samples as follows:



In addition, samples of the three woods in various sizes (some "small" and others "large") should be obtained.

Other items needed for the activity include a pan balance, weights, and rulers. A calculator is an optional, but useful, tool.

PROCEDURE: Students are given the oak, pine, and balsa samples which have the same dimensions and are asked to place them in some order according to how "heavy or light" they feel. This results in the ordering oak-pine-balsa. Then the samples which have different dimensions are used. This presents problems because a small piece of oak may feel as heavy as a larger piece of pine while a much larger piece of balsa may have the greatest weight. It is now time to introduce the definition of density through a series of activities.

a. Each of the wood samples, having the same dimensions, is placed on the balance and the masses are determined.

b. Each one is measured along the length, width, and height. Multiplication of these three quantities yields the volumes of the blocks.

c. Division of mass by volume results in a determination of a ratio; namely, the density of each of the woods. Typical values, in grams per cubic centimeter, follow:

    Balsa.....0.11 to 0.16
    Pine.....0.35 to 0.60
    Oak.....0.60 to 9.90

    (It should be noted that particular wood samples are not identical. For example, the sources for the so-called pine wood differ not only in terms of the type of tree used but also how that tree grew, the knots present, etc. Hence, the density values exhibit a range. However, for a particular set of samples obtained from the same piece of lumber the values will exhibit a more narrow range.)

d. If this activity is performed by the students, results could be

placed on the chalkboard and an average density for each of the woods could be determined.

e. Now the samples with differing dimensions are measured in terms of mass and volume as was done previously with those having the same dimensions. The densities are determined.

f. The results of this show that all of the balsa samples have densities within a very narrow range. The same will be true of the oak and the pine.

g. The concept of density has been used to illustrate a common, derived property of the various woods. No matter what the size or shape or mass of particular wood samples, all samples have densities within a small range.

It should be noted that children often will insist on knowing "what is the 'right' answer." Since this activity makes use of linear measures as well as mass, errors of measurement are expected. That is, one individual may overestimate particular measures while another may underestimate those same quantities. Hence, the obtained values for densities have to vary. Because of these types of measurement errors, averaging is justified. On the other hand, if a student makes an error in division or does not correctly add up the weights on the pan balance, then the obtained density will differ by a large amount. In this case, including such a figure in the averaging process is not justified.

ACTIVITY TWO
Salt Water - Fresh Water

MATERIALS: Four jars with narrow openings (such as jars from olives), index cards, food coloring, Kosher or pickling salt (rather than free flowing table salt which "clouds up" when dissolved in water), water, and two large bottles.

PROCEDURE: Make up a concentrated solution of salt and water in one of the bottles. Place fresh water in the other bottles. Since both the salt water and the fresh water should be the same temperature, these should be made up well before the experiment is to be performed so that they attain room temperature.

a. Put several drops of food coloring in the two "salt water" jars.

b. Fill the two jars to the very top with the salt water. Fill the remaining two jars with fresh water.

c. Place a 3x5 index card over the top of one of the fresh water jars and also on the top of one of the salt water jars. Using the fresh water jar, place your fingers on the index card and turn the jar "upside-down."

d. Release the fingers and the water should remain in the inverted jar.

e. Place the opening of the inverted fresh water jar on the opening of the salt water jar. (The index card should still be between the tops of the two jars.)

f. Then slowly pull out the index card from between the tops of the two jars.

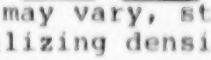
g. Repeat the procedure for the remaining set of jars, making sure that the salt water jar is placed on top of the fresh water jar.

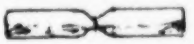
(In effect, the preceding simply directs one to place the opening of the jar containing fresh water on top of the opening of a jar containing salt water. The second part has one place a salt water jar on top of a fresh water jar.)

RESULTS: When the fresh water is placed on top of the salt water, the fresh water simply floats. However, when salt water is placed on top of the fresh water, the salt water sinks. As it sinks, fresh water has to be displaced. Thus, the rising fresh water moves through the sinking salt water producing a mixing effect. This can be observed by noting a decrease in the intensity of the color.

EXPLANATION: In order to explain these events, one should do the following. Equal volumes of salt water and fresh water are placed on the pan balance. The side containing the salt water is more massive, and this may be readily observed. Students are asked to invoke the density concept to account for the observation. It should be concluded that salt water is more dense than is fresh water.

The explanation of what took place involves the notion of density. Since salt water has a greater density than does fresh, the fresh water simply "floats" on top of the more dense salt water. However, when the salt water jar was on top of the fresh water jar, the more dense salt water sinks through the fresh water.

REINFORCEMENT ACTIVITY: Ask students to predict what will occur if the remaining jars (the fresh on top of salt water set) are rotated through 90°--that is, placed in this position:  . While predictions may vary, students who are conceptualizing density will predict that the more dense salt water will "slide beneath" the fresh water, thus producing this effect:



Note: Does one observe fresh water floating on top of salt water in nature? Good, everyday examples of this are pictures of river systems emptying their "fresh" water into the salty oceans. Some of these extend for miles as the river water remains on top of the more dense saline water.

ACTIVITY THREE
Hot Water - Cold Water

The materials needed are the four jars with narrow openings, index cards, food coloring, hot and cold water. The procedures are identical to those in the preceding activity except "cold water" is used in place of "salt water" and "hot water" is used in place of "fresh water." The results are identical to those in activity two.

EXPLANATION: Cold water has a greater density than does hot water. (This may be shown by weighing equal volumes of hot and cold water using a very accurate balance. Since density is defined as mass/volume, the observation that cold water weighs more than does an equal volume of hot water establishes this fact.) Therefore, when the less dense hot water is placed on top of the more dense cold water, the hot water floats. However, when the cold water is placed on top of the hot water, the cold water sinks. As it does this, hot water has to be displaced. Hence the rising hot water moves through the sinking cold water producing a mixing effect. A change in the intensity of the color shows this mixing rather well. In addition, it will be noted that the temperatures (as determined by

touch) of the two jars change significantly as they approach some equilibrium temperature.

The same reinforcing activity should be performed with students making predictions, based on the density concept, and then testing those out.

Note 1: Again, does one encounter this in the everyday world of experience? Of course. In standing bodies of water (undisturbed lakes, swimming pools, etc.), the warmer water is found near the top while the cooler water is beneath it. Hot water heating systems which rely on "gravity feeds" rather than pumps make use of density differences to circulate water. And it should be pointed out that students often make the inference that gases behave the same way in that "hot air rises as cold air sinks." And this is due to the difference in densities.

Note 2: On occasion, an astute individual will ask: "Well, if cold water sinks, why doesn't the lake freeze from the bottom up, rather than from the top down?" This could develop into a research project for the class which will have many spin-offs. The notion of freezing and how it occurs may be one avenue. Others may involve the freezing points of salt versus fresh water. In this region of the country, students often "go off" on the tangent involving the winter use of salt on the ice packed streets. There usually is the person who relates this to the placing of salt on the ice in homemade ice cream makers. Does hot water freeze faster than cold water? Etc., etc., etc. But what is the answer to that original question concerning the freezing of the lake? As teacher-learners, maybe we should do some "research" on this. If we do, we will find that density is involved in the answer.

ACTIVITY FOUR
Liquid "A" - Liquid "B"

Many variations of the basic use of the "four jar" experiment are possible. The procedures are the same as those involving salt water-fresh water. Some liquids that have been used as substitutes follow:

1. *Lemon-Lime diet pop vs. Lemon-Lime non-diet pop*
2. *Sugar water vs. Non-sugar water*
3. *Distilled water vs. Tap water*
4. *Distilled water vs. Well water*
5. *Skim milk vs. Whole milk*

When some of our elementary education majors did this activity with fourth, fifth, and sixth grades in a science mini-course series, children suggested using "very salty water versus not so salty water" (that is, vary the salt content of various solutions), "warm water versus real hot water" (vary the temperatures of the water), "cold salt water versus hot salt water" (change the temperature of the same salt solution), and so forth. As they performed these extensions, they were expected to make predictions using density and then to explain the results using this same concept.

ACTIVITY FIVE
Blocks of Wood in Salt and Fresh Water

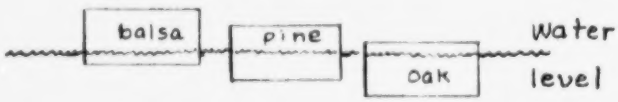
MATERIALS: Two sets of the wood blocks having the same linear measures (from activity one), two clear plastic shoe boxes (or clear glass cake "pans"), concentrated salt water solution, and fresh water.

PROCEDURE: Ask the students to predict the fate of a wood block when it is placed in water. From their experiences, they will say that floating will be the result. Then ask them to predict what will

occur if balsa, pine, and oak are placed in water. If the predictions vary, ask them if the density concept would help.

a. Place the samples of balsa, oak, and pine in a shoe box which is half filled with fresh water.

b. The observation is made that the samples form a "stair-step" pattern:



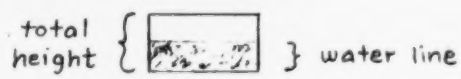
EXPLANATION: As a rule of thumb and in general, a solid floats in a liquid because the density of the solid is less than that of the liquid. Pure water has a density of one gram/cubic centimeter and, therefore, things less dense (such as various woods) should float and things more dense (such as metals) should not. Since the difference in density between the balsa (0.1 g/cc) and the water (1 g/cc) is greatest and oak (0.8 g/cc) versus water is least, the stair-step pattern may be predicted.

c. The next step involves a comparison between the three wood samples in fresh water and another set in salt water. Students are again asked for predictions.

d. When the comparison is made, it is observed that all three wood samples have less submergence in the salt solution. In fact, the balsa appears to be literally resting on the surface much as a waterbug does on a lake's surface.

REINFORCEMENT ACTIVITY: Ask students to estimate the ratio (or the percentage) of the amount of the height of block which is submerged to the total height of the block. While such estimates are bound to vary, they represent rough approximations of the density of the wood.

A more precise estimate may be obtained if the height of the wood is measured. The sample is gently placed in the water and removed as quickly as possible. The water line is measured (this represents the amount submerged) as soon as possible (because water is absorbed by the wood thus producing a larger water line than would be present without this action.)



The ratio of water line height to total height represents another determination of the density of the sample.

Note: Again, science phenomena should be related to the world of experience to make them meaningful. Children are quick to point out that their experiences with ocean swimming (and in rare cases, swimming in the Great Salt Lake) are consistent with the behavior of the wood in salt and in fresh waters. It may also be mentioned that ships have a fresh water "cargo limit" as well as an ocean water line. That is, a vessel fully loaded at a Great Lakes port may well add additional cargo as it reaches a salt water embarkation point. (For example, grain ships leaving Duluth on Lake Superior are trans-loaded as they enter the saline waters of the far reaches of the St. Lawrence Seaway.) And, of course, the opposite operation is performed as an ocean liner passes into fresh waters.

SUMMARY

Through activities such as the preceding, the conceptualization of

density may be acquired by children rather than a memorized definition which is often meaningless and soon forgotten. Perhaps we are now ready for the old question: "Which weighs more--a pound of feathers or a pound of steel?" (Of course they both weigh the same if weights are determined at the same location with the same instruments and at the same time.) The fact that many respond to the question with the answer "steel" is an indication that weight and density are really not part of their conceptual framework. And perhaps this is due to the way they have been "taught."

Science, as well as all areas of the curriculum, is dependent upon definitions and conventions. Unless these become internalized, unless they become part of our working vocabulary, unless they become conceptualized--then science, as well as those other areas, will be something that is confusing, feared, and held in awe. But it need not be if the discipline is approached in a "hands-on," experiential manner rather than through a "read and tell" methodology.

Dr. Gaides received his advanced degrees in Science Education from the University of Illinois at Urbana and has taught at Miami University, the University of Illinois, and is currently on the elementary education staff at the University of North Dakota, Grand Forks. He has worked with many teachers through Continuing Education courses, and the activities described in this article are an integral part of his "Enriching Science in the Elementary School" workshop. He also has provided many inservice sessions for interested schools.